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A PLATE HEAT EXCHANGER

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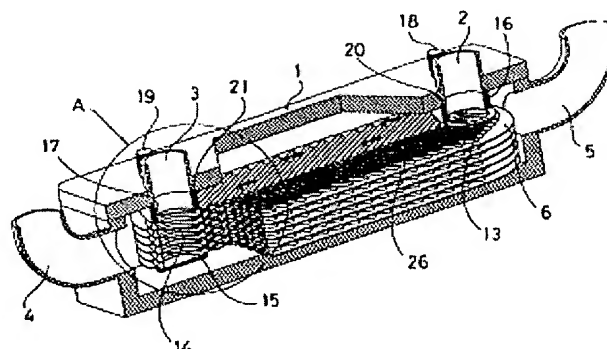
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In a plate heat exchanger the heat transfer plates (7, 8) are in pairs welded together to form cassettes (6). The two plates in every cassette bear on each other via corrugation ridges (25), which are crossing each other and create a flow path (33) between them for a first fluid. The cassettes (6) bear on each other via elevations (26), which are higher than the corrugation ridges (22) on the outsides of the cassettes. Between the cassettes (6) flow paths (34) are delimited for a second fluid. The main directions of flow for the two fluids are in parallel. Each one of the mentioned elevations (26) is elongated and extends with its longitudinal axis substantially in parallel with the main directions of flow for the fluids, bridging at most two valleys (23) between corrugation ridges (22) extending next to each other.



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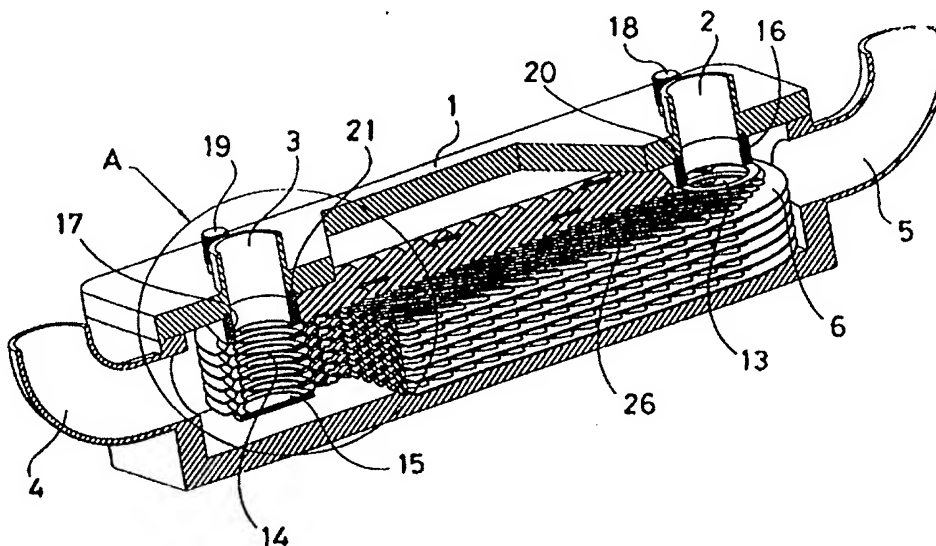
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(57) Abstract

In a plate heat exchanger the heat transfer plates (7, 8) are in pairs welded together to form cassettes (6). The two plates in every cassette bear on each other via corrugation ridges (25), which are crossing each other and create a flow path (33) between them for a first fluid. The cassettes (6) bear on each other via elevations (26), which are higher than the corrugation ridges (22) on the outsides of the cassettes. Between the cassettes (6) flow paths (34) are delimited for a second fluid. The main directions of flow for the two fluids are in parallel. Each one of the mentioned elevations (26) is elongated and extends with its longitudinal axis substantially in parallel with the main directions of flow for the fluids, bridging at most two valleys (23) between corrugation ridges (22) extending next to each other.

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A plate heat exchanger

This invention concerns a plate heat exchanger at which a plurality of plates are so arranged as to create plate interspaces between them for flowing through of two fluids; inlets and outlets for the mentioned fluids are so arranged that a first one of the fluids is led through every other plate interspace and a second one of the fluids is led through the rest of the plate interspaces in main directions of flow, which are in parallel with each other; each plate is provided with a press pattern which is such that the plate on its both sides shows ridges and valleys extending next to each other, which form an angle with the mentioned main directions of flow; ridges of the mentioned kind in a crossing manner bear on ridges of the same kind in those of the mentioned plate interspaces, which are created for flowing through of said mentioned first fluid; every other plate has, on that one of its sides, which is turned to a plate interspace created for flowing through of the mentioned second fluid, elevations created by pressing of the plate, which elevations are higher than those ridges that are on the same side of the plate; and the mentioned elevations at every other plate bear on the adjacent plate in the mentioned plate interspace, which is created for flowing through of the mentioned second fluid, in such a way that opposite ridges at the two plates are kept at a distance from each other. By the design of the plates in this manner the fact is achieved that the mentioned second fluid meets a considerably lower flow resistance than the mentioned first fluid at the flowing of the fluids through the plate heat exchanger.

In GB-1,071,116 a plate heat exchanger of this kind is shown, at which special elevations are designed for keeping the plates at a distance from each other in every other plate interspace meant for flowing through of a gaseous fluid, which distance is larger than the distance between the plates in the rest of the plate interspaces aimed for the flowing through of a fluid in a liquid state. The special elevations are created on the tops of those ridges that are crossing each other in the plate interspaces for the gaseous fluid.

The object of this invention is to create a plate heat exchanger of the kind mentioned by way of introduction, at which heat exchanger the plates are designed so as to be utilized more effectively than what is the case with the known heat exchanger according to GB-1,071,116 for the desired heat transfer between the fluids.

This object can, according to the invention, be achieved by each one of the mentioned elevations on every other plate being elongated and extending, with its longitudinal axis, substantially in parallel with the mentioned main directions of flow, thereby bridging at the most two valleys between ridges extending next to each other, which ridges are created on the same side of the plate as the elevation in question.

By such an arrangement for the mentioned elevations these can be given any wanted height without any need to forego the present desire concerning the design of the ridges and valleys extending next to each other. Thus, it is desirable at - and by - the pressing of the mentioned ridges and valleys in a plate to create the largest possible area enlargement of the plate, so that

the plate may be used to a maximum for the present heat transfer.

At a plate which is designed in accordance with GB-
1,071,116 (the figures 5 and 6) the largest possible
area enlargement of the plate is decided by the local
area enlargement that is created in the areas for the
extra elevations on the top of the mentioned ridges.
Thus if a maximum area enlargement is created in the
areas for the extra elevations, this means that the
ridges as for the rest are created with a somewhat
smaller area enlargement than that one at a maximum for
the plate.

At a plate designed in accordance with the invention the
same maximum area enlargement can be achieved in the
areas for the mentioned ridges as in the areas for the
elevations. Accordingly, the top of each one of the
mentioned ridges may, as seen in the form of a cross-
section through the ridge, be given the same radius of
curvature as the top of an elongated elevation according
to the invention, as seen in a cross-section through the
elevation. By the fact that every elevation is extending
substantially in parallel with the main direction of
flow for the mentioned second fluid the elevation can be
designed so as to occupy a very small part of the flow
area for the mentioned second fluid. In order for the
elevations of the plates to be made as narrow as
possible it is convenient for all plates in the plate
heat exchanger to be provided with such elevations and
that the elevations of one plate bear on the elevations
of an adjacent plate. This is especially important when
the plates are elongated and have its longitudinal axis
extending in parallel with the main directions of flow
for the heat exchanging fluids, since in this case the

flow areas for the two fluids between the plates are relatively constricted. The heat exchange is normally aimed to take place in counter flow for heat exchanging fluids but alternatively following flow for the fluids may occur.

As mentioned above each one of the mentioned elevations bridges at the most two valleys situated between ridges extending next to each other. Preferably, however, every elevation only bridges one valley between two adjacent ridges. The reason for this is that every elevation of this kind which is created on one side of a plate creates a recess in the plate on the other side of this plate. This recess will constitute an unwanted flow passage for the mentioned first fluid across a ridge formed on this other side of the plate. An important condition for the plate heat exchanger according to the invention to be as effective as possible is that such unwanted flow passages for the mentioned first fluid are as short as possible.

The present invention can be utilized in connection with any type of plate heat exchanger. Accordingly it can be used no matter which means are used for delimiting the flow paths for the heat exchanging fluids between the plates. Such means may for example be exchangeable gaskets of elastic material or permanent weld or braze seams between the plates.

The invention is especially well suited for so called brazed plate heat exchangers, at which adjacent plates are - at least in every other plate interspace - brazed together in all places where the plates are in contact with each other, i.e. not only along the edges of the plates but also - and above all - at a plurality of

places distributed over the substantial heat transfer areas of the plates.

At such a plate heat exchanger according to the invention the plates are preferably brazed together in those plate interspaces that shall be flown through by the mentioned first fluid. In those plate interspaces a lot of connection places are created in this manner where the ridges of the respective plates in a crossing manner bear on each other. Hereby the mentioned first fluid may be allowed to have a considerably higher pressure than the mentioned second fluid without this relationship calling for special demands concerning the design of the mentioned elevations in the plate interspaces for the mentioned second fluid that shows a relatively low pressure. The reason is that these elevations need not transfer any forces between the plates which are dependent upon the high pressure with which the mentioned first fluid shall flow through the plate heat exchanger and they may for this reason be very few in number. This means that the elevations may occupy the smallest possible area of the present flow area for the mentioned second fluid.

It has been stressed above that, for a certain reason, each one of the mentioned elevations should bridge only one of those valleys that are created between the ridges in the plate interspaces for the mentioned second fluid. This is important also for another reason. The design of elevations of the mentioned kind may get into conflict with a wish that as many as possible and as evenly distributed contact and connection places as possible will be achieved between the present plates in the plate interspaces for the mentioned first fluid. The shorter the elevations are made the smaller the risk for such a

conflict will be or, alternatively, the smaller the negative consequences of such a conflict will be if this is not to be avoided.

5 The invention will be described in the following in connection with the accompanying drawing, in which

figure 1 shows a plate heat exchanger according to the invention, partly in section,

10

figure 2 shows an enlargement of a part A of figure 1,

figure 3 shows an enlargement of a part B of figure 2,

15 figure 4 shows a cross-section through some heat transfer plates, that are also shown in figure 3,

figures 5a and b show two heat transfer plates,

20 figures 6a, b and c show a plan view and two sections of a part C of the heat transfer plate of figure 5b, respectively,

figure 7 shows the heat transfer plates at a plate heat
25 exchanger according to figure 1 arranged at a distance from each other, and

figure 8 shows a cross-section, alike figure 6b of a
part of a heat transfer plate in an alternative
30 embodiment.

In the drawing a plate heat exchanger is shown that is specially aimed for a heat exchange between a relatively small flow of oil and a relatively large flow of water.

35 In this actual case the oil is of a relatively high

pressure, while the water is of a relatively low pressure. Furtheron the oil shall in this case be chilled with the aid of the water.

5 As is evident from the figure 1 the plate heat exchanger incorporates a housing 1, which has an inlet 2 and an outlet 3 for the oil and an inlet 4 and an outlet 5 for the water. Inside the housing 1 a pile of cassettes 6 is placed, which cassettes each one consists of two
10 elongated heat transfer plates 7 and 8 (see figure 5).

The two plates 7,8 in every cassette 6 are welded together along its circumferential edges and delimit between them a flow path for oil which shall be chilled
15 within the plate heat exchanger. The plates 7,8 have got through holes 9-12 at their ends, which holes are situated in line with the inlet 2 and the outlet 3, respectively, for the oil. Adjacent cassettes 6 are welded together with each other around the holes 9-12,
20 respectively, so that the holes constitute an inlet channel 13 and an outlet channel 14, respectively, extending through the whole pile of cassettes 6.

As is evident from the figures 1 and 2 a circular washer
25 15 is arranged right before the outlet channel 14 below the lowermost cassette 6, so that it covers the hole through the lowermost plate in this cassette 6. The washer 15 is sealingly brazed at the lowermost plate and around the mentioned hole. In a corresponding manner a
30 washer (not shown) is arranged right before the inlet channel 13 underneath the lowermost cassette 6.

Between the uppermost cassette 6 and an upper wall of the housing 1 a connection piece 16 is arranged showing
35 a through hole, which is coaxial with the oil inlet 2

of the housing and with the inlet channel 13 of the cassette pile. In a corresponding manner a similar connection piece 17 is arranged at the oil outlet 3 of the housing 1.

5

The connection pieces 16 and 17, that are brazed at the uppermost cassette 6, each one has two threaded pin bolts 18 and 19, respectively, (figure 7), which extend out through holes in the upper wall of the housing 1 (figure 1). The pile of cassettes may be fixed in relation to the housing 1 by nuts (not shown), that shall be threaded upon the pin bolts 18 and 19, by being pressed towards the inside of the upper wall of the housing 1. Gaskets 20 and 21 are arranged to seal between the housing 1 and the connection pieces 16 and 17, respectively, around the oil inlets 2 and 3.

10
15

In every cassette the plates are situated at a distance from each other in annular areas around the holes 9-12, respectively. This is best shown in figure 2. Thus oil may enter through the inlet 2 and the inlet channel 13, be distributed and flow through all plate interspaces within the cassettes 6 and leave the plate heat exchanger via the outlet channel 14 and the outlet 3.

20
25

Water may enter through the inlet 4, flow through compartments constituted between adjacent cassettes 6 and leave the plate heat exchanger through the outlet 5.

30

The oil and the water accordingly flow through the pile of cassettes 6 in a counterstream along main flow paths that are substantially in parallel with each other.

In figures 5a and b two plates 7 and 8, respectively, of thin plate are shown, that may be brazed together to

35

form a cassette 6. The plates 7 and 8 are identically designed and in figure 5 one of them is shown turned 180° in its own plane in relation to the other one.

5 Each one of the plates is provided with a press pattern of corrugations comprising ridges and valleys in parallel. On one side of the plate (see figure 5a) ridges 22 and valleys 23 are created. As shown in figure 6b the ridges 22 constitute valleys 24 on the other side of the
10 plate. In a corresponding manner the valleys 23 on one side of the plate constitute ridges 25 on the other side of the plate. The ridges and the valleys are pressed in a so called herringbone pattern so that when a plate 7 is placed on a plate 8, as these plates are oriented in
15 the figure 5, the ridges and the valleys of the plates will cross each other.

Besides the press pattern with ridges and valleys each one of the plates 7 and 8 has got elongated pressed
20 elevations 26. These elevations extend in the longitudinal direction of the plates and are somewhat higher than the ridges 22. Each one of the elevations 26 extends from the top of a ridge 22 to the top of an adjacent ridge 22, bridging the valley 23 in between.
25 This is best seen in the figures 6a - c, where the figures 6b and c are cross-sections through a plate taken along the lines b-b and c-c, respectively, in the figure 6a.

30 The plates 7 and 8 in figure 5 have edge parts 27, 28 extending circumferentially around the respective plates. These edge parts are present in the same plane as the tops of the ridges 25 (see figure 4). In other words the ridges 22 and the elevations 26 start from
35 this plane.

Around their through holes 9-12 the plates in the figure 5 have annular areas 29-32, which all are situated in a plane that extends through the tops of the elevations 26.

5

At the creation of a cassette 6 the plates 7 and 8 are laid against each other with those of their respective sides that are not visible in figures 5a and b. Hereby the edge parts 27,28 of the plates will get into contact with each other, whereby the ridges 25 on the one plate will bear on the ridges 25 on the other plate in a crossing manner as is obvious from the figure 3.

By piling of a plurality of cassettes upon each other the annular areas 29-32 and the elevations 26 at one cassette will bear on similar annular areas and elevations at adjacent cassettes in the constructed pile. This is seen from the figures 2-4. Every elevation 26 will thus bear on a similar elevation 26 along its entire length.

In practice all the plates that shall be a part of the heat exchanger will be piled at the manufacture of a plate heat exchanger according to the invention in the way illustrated in figure 7. Also the connecting pieces 16,17 and the washers 15 will be brought together with sufficient brazing material between those plates and other parts of the heat exchanger that will be brazed together. Thus in every cassette 6 the two plates in addition to along their edges will be brazed together, at all those places where the ridges 25 of the plates bear on each other in a crossing manner. Adjacent cassettes will be brazed together at their elevations 26 in addition to their annular areas 29-32.

35

From figure 4 those flow paths are evident which the cassettes 6 delimit within the plate heat exchanger for the oil and the water, respectively. The flow paths for the oil, created within the cassettes 6, are denoted by 33, while the flow paths for the water, created between the cassettes 6, are denoted by 34.

As is evident from the figure 6b the ridges 22 on one side of a plate are broader than the ridges 25 on the other side of the plate. According to a preferred embodiment of the invention the press pattern on the plates is however such that the ridges on one side of a plate have the same form and size as the ridges on the other side of the plate. Hereby an optimum area enlargement of the plate may be achieved at the pressing of its corrugation pattern. A plate which is pressed in this way is illustrated in figure 8, which shows a cross-section of the same kind as in figure 6b. Figure 8 shows two ridges 22a on one side of a plate, one ridge 25a on the other side of the plate and an elevation 26a that extends between the tops of the ridges 22a, bridging a valley 23a between the ridges 22a. The elevation 26a is obviously somewhat higher than the ridges 22a.

At a plate heat exchanger according to the invention designed in accordance with what is described above the flow paths 34 for the water between the cassettes 6 achieve a larger flow area than the flow paths 33 for the oil within the cassettes. This is due to the fact that the elevations 26 keep the ridges 22 of adjacent cassettes 6 at a distance from each other.

By the fact that the plates in every cassette are brazed together at all those places where the ridges 25 bear on

each other in a crossing manner the oil may be allowed to flow through the heat exchanger with a very high pressure without the need for holding the plates pressed together with the corresponding large forces. The water
5 can accordingly be allowed to flow through the heat exchanger with a much lower pressure than the oil.

The cassettes need not be brazed together at their elevations 26 bearing on each other, since all the
10 cassettes, including the uppermost and the lowermost cassette in figure 1, are so arranged as to be bypassed by water on both sides. To avoid vibrations for the cassettes during operation of the heat exchanger the cassettes are however conveniently held together in one
15 way or another. As an alternative to brazing together of the cassettes via the elevations 26 the cassettes may be held pressed together against each other with the aid of a convenient mechanical device.

Claims

1. A plate heat exchanger at which
 - 5 - a plurality of plates (7,8) are so arranged as to create plate interspaces (33,34) between them for a flowing through of two fluids,
 - 10 - inlets (2,4) and outlets (3,5) for the mentioned fluids are so arranged that a first one of the fluids is led through every other plate interspace (33) and a second one of the fluids is led through the remaining plate interspaces (34) in main direc-
15 tions of flow, which are in parallel with each other,
 - every plate (7,8) is provided with a press pattern which is such that the plate on its both sides shows
20 ridges (22,25) and valleys (23,24) extending next to each other, which form an angle with the mentioned main directions of flow,
 - 25 - ridges (25) of the kind mentioned bear on ridges (25) of the same kind in a crossing manner in those of the mentioned plate interspaces that are created for a flowing through of the mentioned first fluid,
 - every other plate has, on that one of its sides
30 which is turned to a plate interspace (34) created for a flowing through of the mentioned second fluid, elevations (26) created by pressing of the plate, which elevations (26) are higher than the ridges (22) situated on the same side of the plate, and

- the mentioned elevations (26) at every other plate bear on the adjacent plate in the mentioned plate interspace (34), created for a flowing through of the mentioned second fluid in such a way that
5 opposite ridges (22) on the two plates are kept at a distance from each other,

c h a r a c t e r i z e d i n

- 10 that each one of the mentioned elevations (26) at every other plate is elongated and extends with its longitudinal axis substantially in parallel with the mentioned main directions of flow, bridging at the most two valleys (23) between ridges (22) extending next to each
15 other, which are formed on the same side of the plate as the elevation (26) in question.

2. A plate heat exchanger according to claim 1, at which each one of the mentioned elevations (26) bridges
20 only one valley (23) between two adjacent ridges (22).

3. A plate heat exchanger according to claim 1 or 2, at which all plates (7,8) are provided with elevations (26) of the mentioned kind in those plate interspaces (34)
25 that are created for a flowing through of the mentioned second fluid.

4. A plate heat exchanger according to claim 3, at which elevations (26) of the mentioned kind at a plate
30 bear on elevations (26) of the same kind at an adjacent plate.

5. A plate heat exchanger according to any of the preceding claims, at which the plates (7,8) are welded
35 together with each other where the mentioned ridges (25)

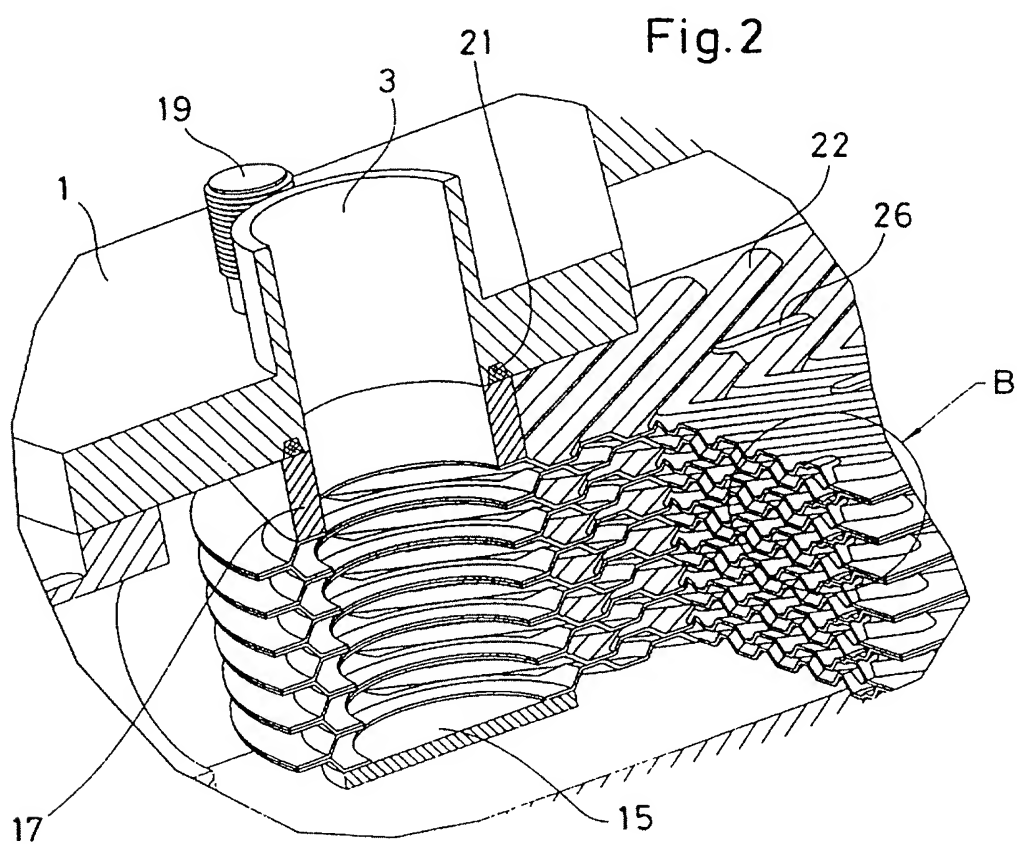
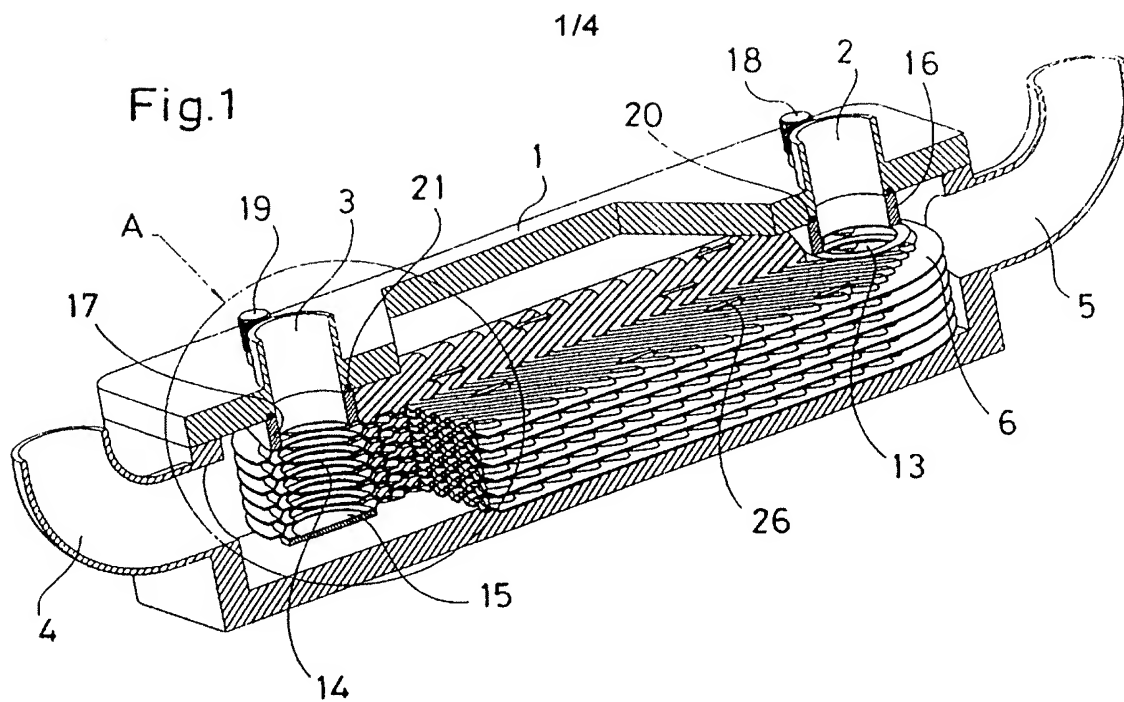
bear on each other in a crossing manner in the plate interspaces (33) for the mentioned first fluid.

5 6. A plate heat exchanger according to any of the preceding claims, at which the plates (7,8) are elongated and extend with their longitudinal axes in parallel with the mentioned main directions of flow.

10 7. A plate heat exchanger according to any of the preceding claims, at which the press pattern of the plates is such that the ridges (22a) on one side of a plate have substantially the same form and dimension as the ridges (25a) on the other side of the plate.

15 8. A plate heat exchanger according to any of the preceding claims, at which the plates (7,8) in pairs create cassettes (6) and are thereby welded together in every cassette partly along edge parts (27,28) of the plates partly at those places where the ridges (25) of
20 the plates bear on each other in a crossing manner.

9. A plate heat exchanger according to claim 8, at which the cassettes (6) bear on and are brazed together with each other via the mentioned elevations (26).



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Fig. 3

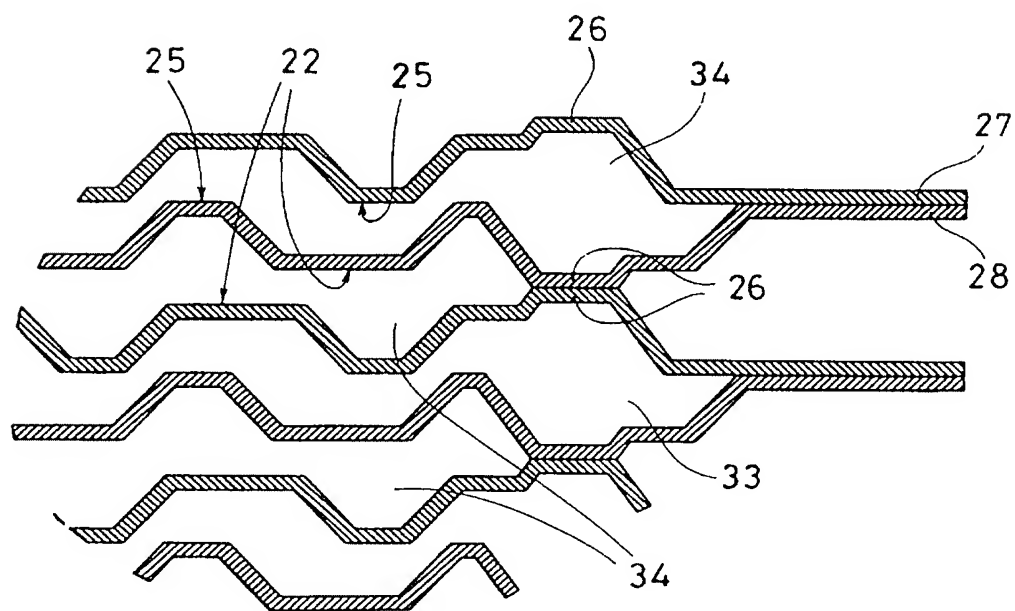
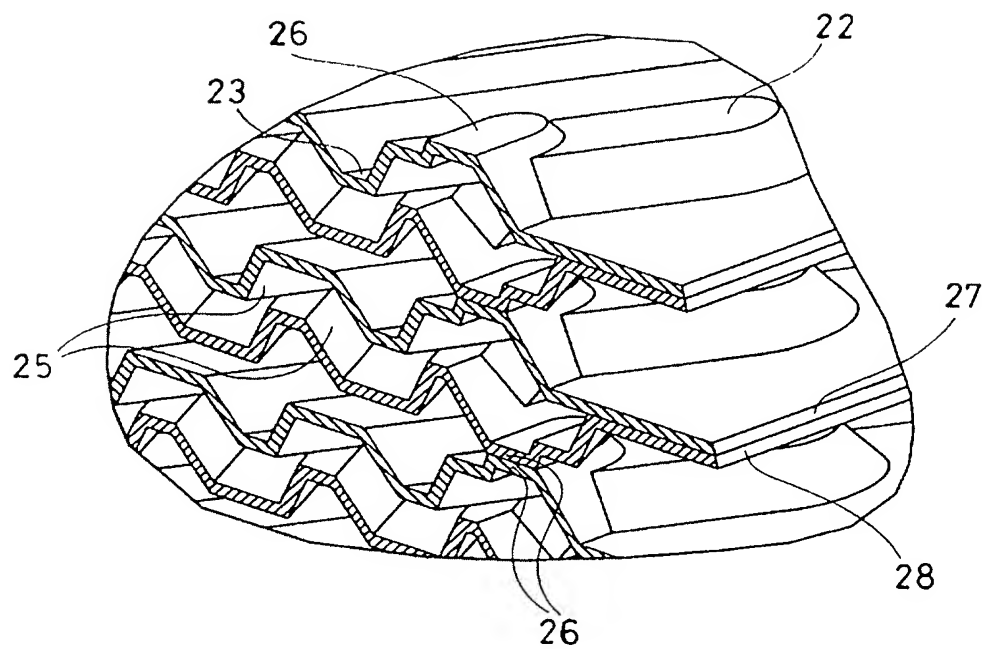


Fig. 4

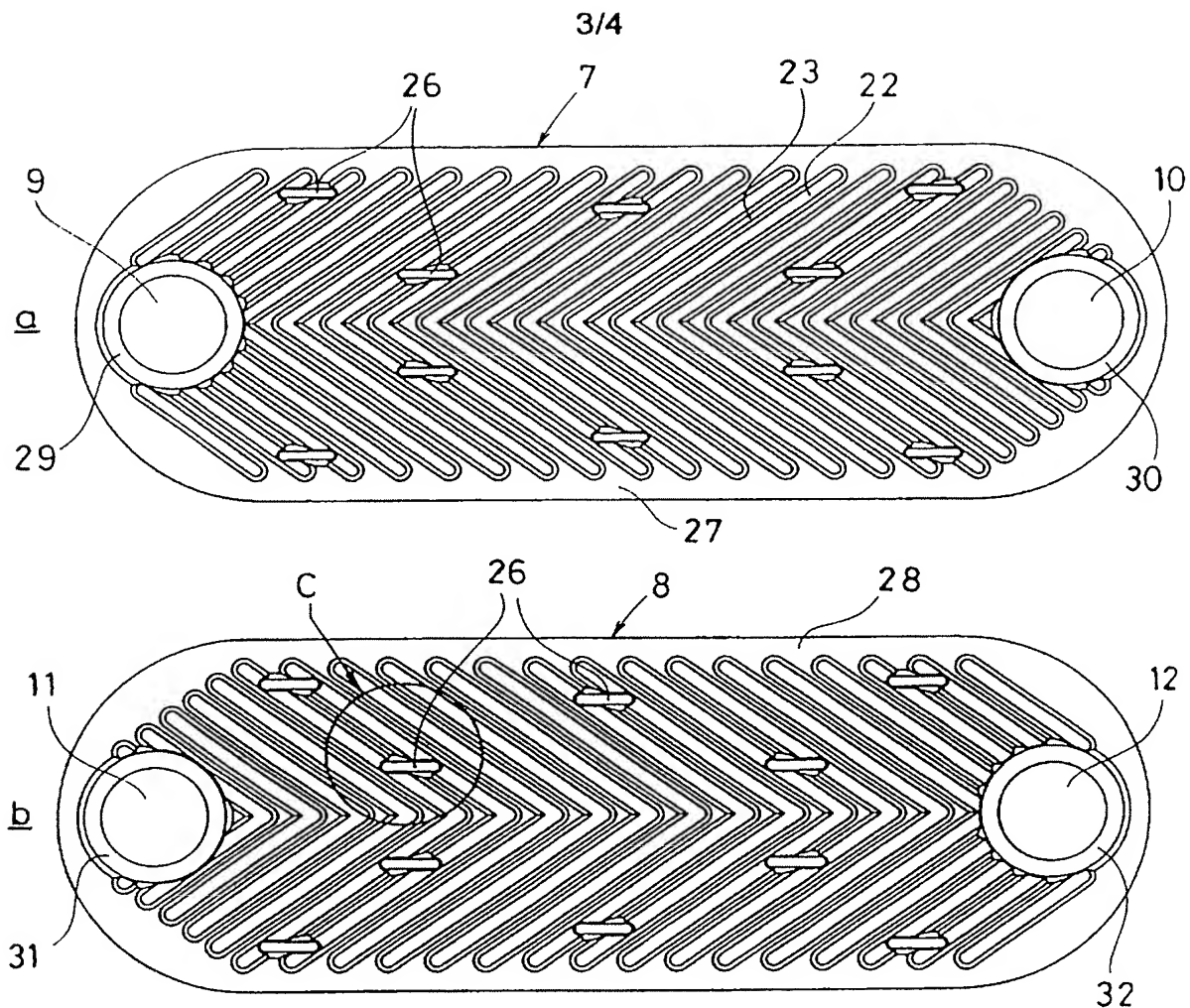


Fig. 5

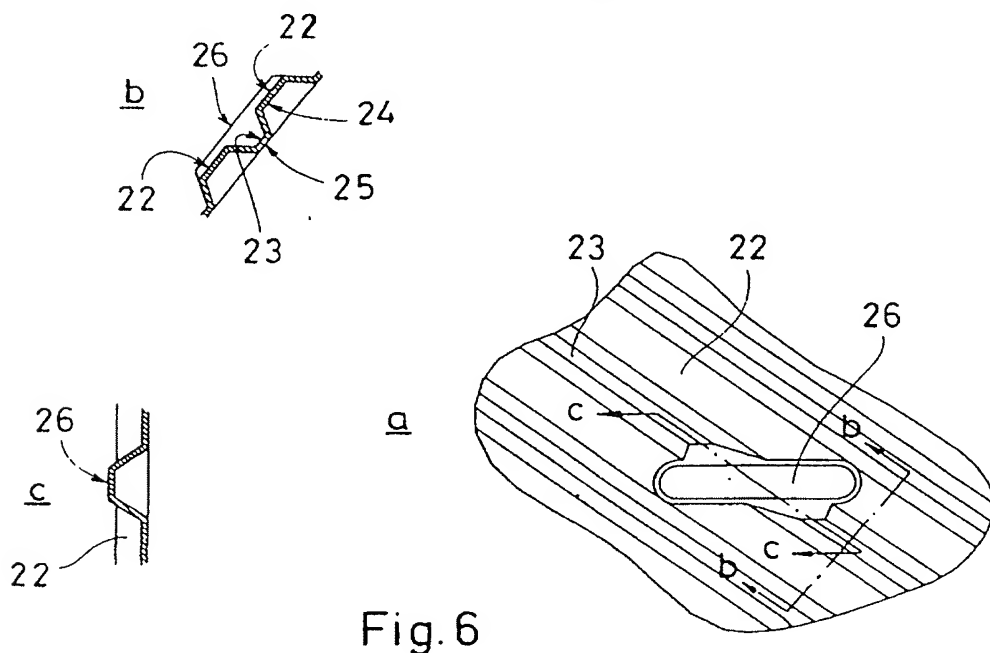


Fig. 6

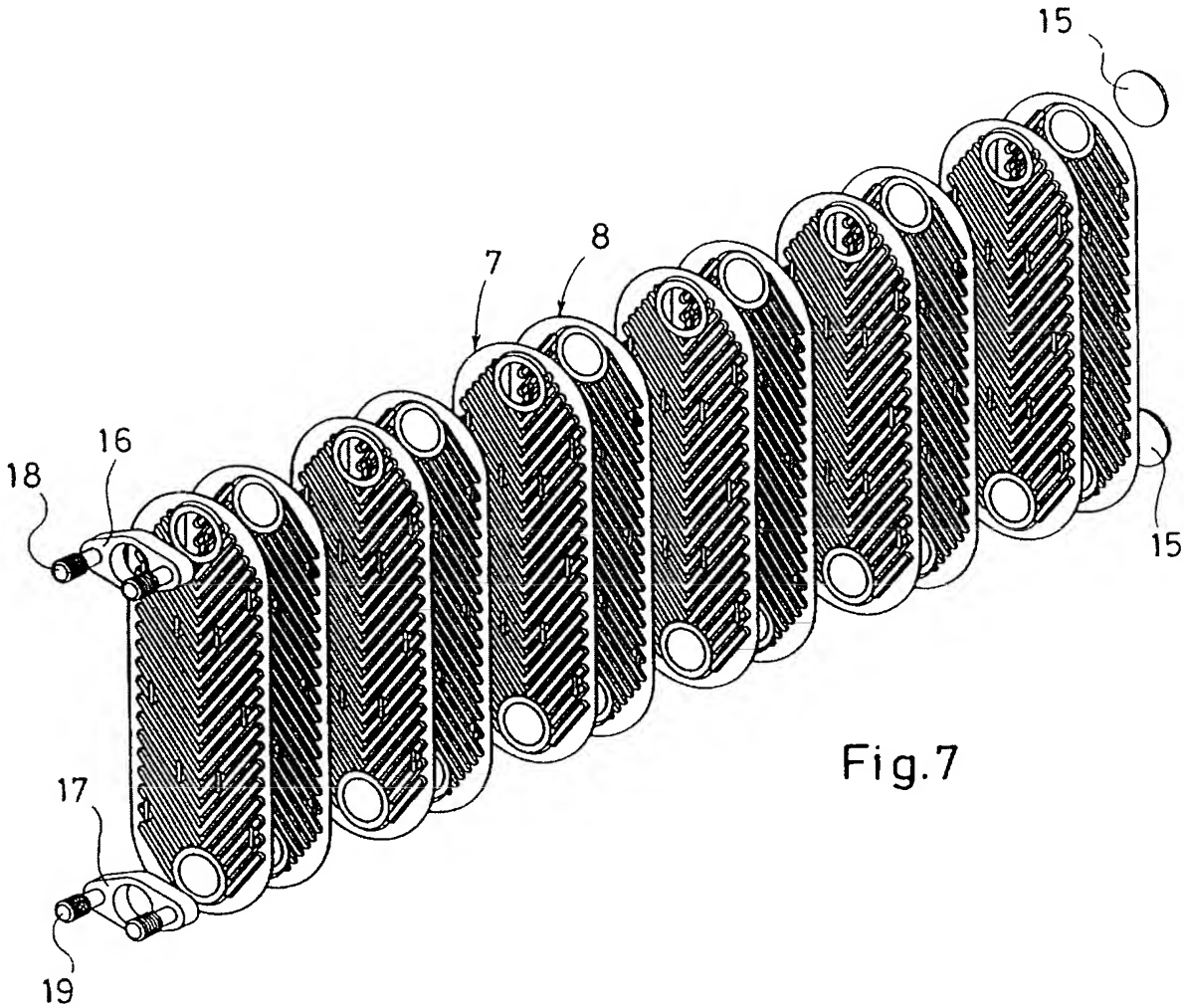


Fig. 7

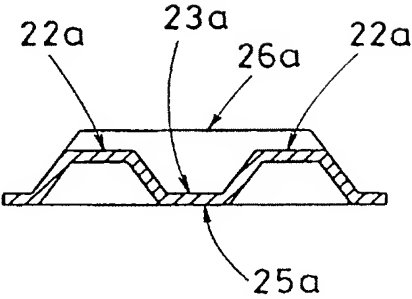


Fig. 8

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/00641

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F28F 3/00, F28D 9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F28D, F28F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 8701795 A1 (ALFA-LAVAL THERMAL AB), 26 March 1987 (26.03.87) --	1,2
Y	US 2610835 A (R.P.L. HYTTE), 16 Sept 1952 (16.09.52), column 3, line 32 - line 39, figure 2 --	1,2,8,9
Y	US 3931854 A (IVAKHNENKO ET AL), 13 January 1976 (13.01.76)	8,9
A	--	3,4
A	SE 320678 B (ALFA-LAVAL AB), 16 February 1970 (16.02.70), page 4, line 14 - line 26 --	1,2

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

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- "O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search

23 July 1997

Date of mailing of the international search report

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/00641

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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A	CH 622608 A5 (AKTIEBOLAGET CARL MUNTERS), 15 April 1981 (15.04.81), page 4, line 39 - line 50 --	1,7
A	SE 127970 B (AKTIEBOLAGET BOLINDER-MUNKTELL), 11 April 1950 (11.04.50) -- -----	5-8

INTERNATIONAL SEARCH REPORT
Information on patent family members

01/07/97

International application No.
PCT/SE 97/00641

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